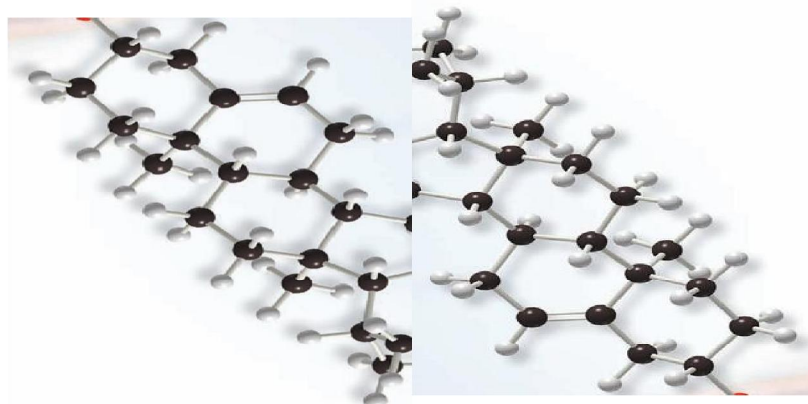


General Organic and Biological Chemistry



Ass Prof Dr.Mokhtar Al-Ghorafi

AMINO ACIDS, PROTEINS, AND ENZYMES

❖ **Keratin and collagen**, for example, form long insoluble fibers, giving strength and support to tissues.

Hair, horns, hooves, and fingernails are all made up of keratin.

❖ **Collagen** is found in bone, connective tissue, tendons, and cartilage.

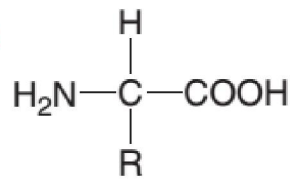
❖ **Membrane proteins** transport small organic molecules and ions across cell membranes.

❖ **Insulin**, the hormone that regulates blood glucose levels, and hemoglobin, which transports oxygen from the lungs to tissues, are proteins.

❖ **Enzymes** are proteins that catalyze and regulate all aspects of cellular function.

Proteins

Proteins are biomolecules that c
bonds, formed by joining **amino**



e

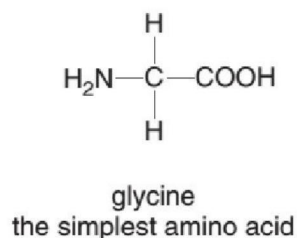
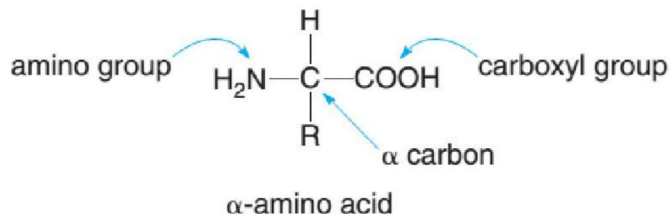
amino acid

❖ **Unlike lipids and carbohydrates, which the body stores for use when needed, protein is not stored so it must be consumed on a daily basis.**

❖ **The current recommended daily intake for adults is 0.8 grams of protein per kilogram of body weight.**

GENERAL FEATURES OF AMINO ACIDS

Amino acids contain two functional groups—an amino group (NH₂) and a carboxyl group (COOH).



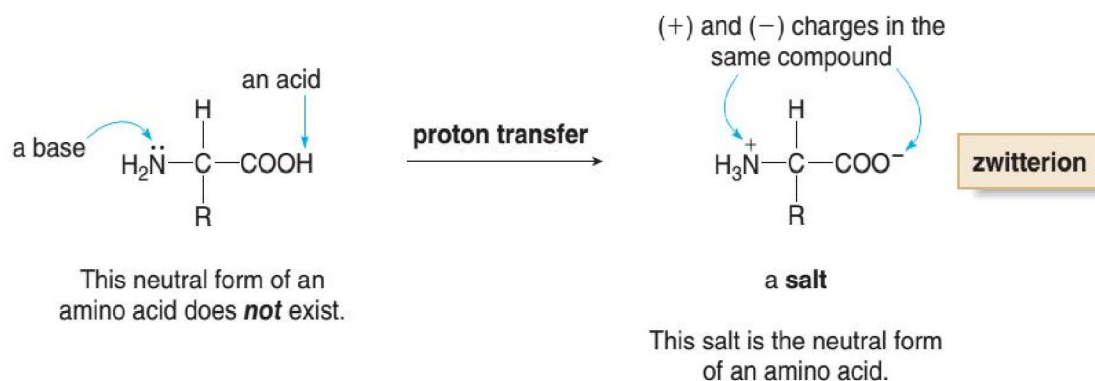
❖ **The 20 amino acids** that occur naturally in proteins differ in the identity of **the R group bonded to the α carbon**. The R group is called the side chain of the amino acid.

❖ **The simplest amino acid, called glycine, has $R = H$** . Other side chains may be simple alkyl groups, or have additional functional groups **such as OH, SH, COOH, or NH₂**

❖ **Amino acids** with an additional **COOH group** in the side chain are called **acidic amino acids**.

❖ Those with an additional **basic N atom** in the side chain are called **basic amino acids**.

❖ All others are **neutral amino acids**.



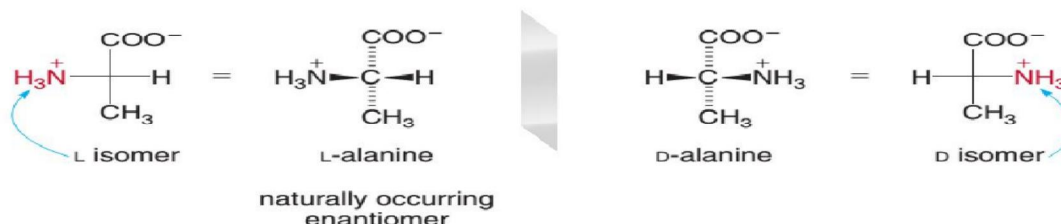
❖ **Humans can synthesize only 10** of the 20 amino acids needed for proteins.

❖ **The remaining 10, called essential amino acids, must be obtained from the diet.**

STEREOCHEMISTRY OF AMINO ACIDS

❖ Except for the simplest amino acid, glycine, all other amino acids have a chirality center—a carbon bonded to four different groups on the α carbon.

❖ Thus, an amino acid like alanine ($R = CH_3$) has two possible enantiomers, drawn below in both three-dimensional representations



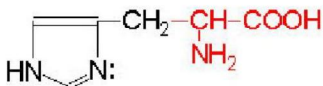
- L Amino acids have the $-NH_3^+$ group on the *left* side in the Fischer projection. Common naturally occurring amino acids are L isomers.
- D Amino acids have the $-NH_3^+$ group on the *right* side in the Fischer projection. D Amino acids occur infrequently in nature.

Amino Acid	Symbol	Structure*			Properties
Glycine	Gly - G	$\begin{array}{c} \text{H}-\text{CH}-\text{COOH} \\ \\ \text{NH}_2 \end{array}$			Neutral, nonpolar
Alanine	Ala - A	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{COOH} \\ \\ \text{NH}_2 \end{array}$			Neutral, nonpolar
Valine	Val - V	$\begin{array}{c} \text{H}_3\text{C} \\ \\ \text{H}_3\text{C}-\text{CH}-\text{CH}-\text{COOH} \\ \\ \text{NH}_2 \end{array}$			Neutral, nonpolar
Leucine	Leu - L	$\begin{array}{c} \text{H}_3\text{C} \\ \\ \text{H}_3\text{C}-\text{CH}-\text{CH}_2-\text{CH}-\text{COOH} \\ \\ \text{NH}_2 \end{array}$			Neutral, nonpolar
Isoleucine	Ile - I	$\begin{array}{c} \text{H}_3\text{C}-\text{CH}_2-\text{CH}-\text{CH}-\text{COOH} \\ \\ \text{H}_3\text{C} \\ \\ \text{NH}_2 \end{array}$			Neutral, nonpolar

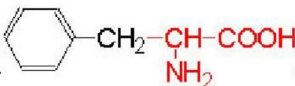
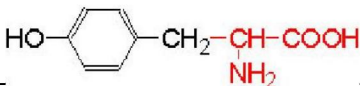
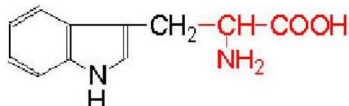
Non-Aromatic Amino Acids with Hydroxyl R-Groups					
Serine	Ser - S	$\text{HO}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Neutral,polar
Threonine	Thr - T	$\text{H}_3\text{C}-\underset{\text{HO}}{\text{CH}}-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Neutral,polar
Amino Acids with Sulfur-Containing R-Groups					
Cysteine	Cys - C	$\text{HS}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Neutral,S, polar
Methionine	Met-M	$\text{H}_3\text{C}-\text{S}-(\text{CH}_2)_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Neutral,S, polar

Acidic Amino Acids and their Amides					
Aspartic Acid	Asp - D	$\text{HOOC}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Acidic,polar
Asparagine	Asn - N	$\text{H}_2\text{N}-\underset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Acidic,polar
Glutamic Acid	Glu - E	$\text{HOOC}-\text{CH}_2-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Acidic,polar
Glutamine	Gln - Q	$\text{H}_2\text{N}-\underset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$			Acidic,polar

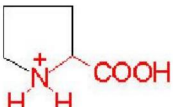
Basic Amino Acids

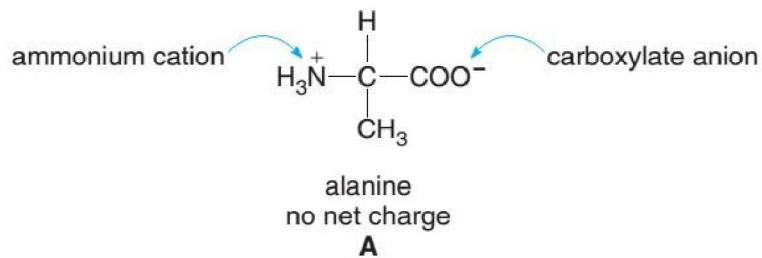
Arginine	Arg - R	$\begin{array}{c} \text{HN}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}-\text{COOH} \\ \\ \text{C}=\text{NH} \\ \\ \text{NH}_2 \end{array}$	1.8	9.0	Basic,polar
Lysine	Lys - K	$\text{H}_2\text{N}-(\text{CH}_2)_4-\text{CH}-\text{COOH}$	2.2	9.2	Basic,polar
Histidine	His - H		1.8	9.2	Basic,polar

Amino Acids with Aromatic Rings

Phenylalanine	Phe - F		2.2	9.2	Neutral,nonpolar
Tyrosine	Tyr - Y		2.2	9.1	Neutral,polar
Tryptophan	Trp-W		2.4	9.4	Neutral,s. polar

Imino Acids

Proline	Pro - P		2.0	10.6	Neutral,nonpolar
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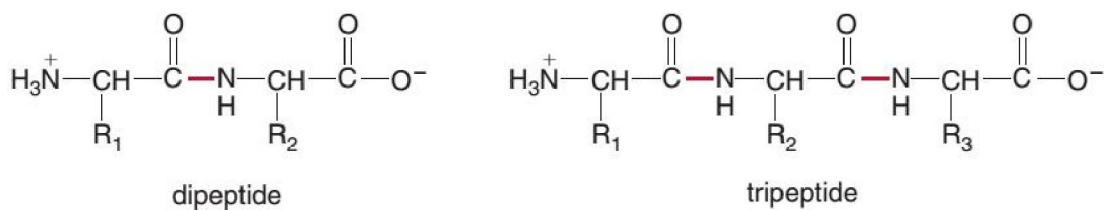


PEPTIDES

❖ When amino acids are joined together by amide bonds, they form larger molecules called **peptides** and proteins.

❖ A **dipeptide** has two amino acids joined together by one amide bond.

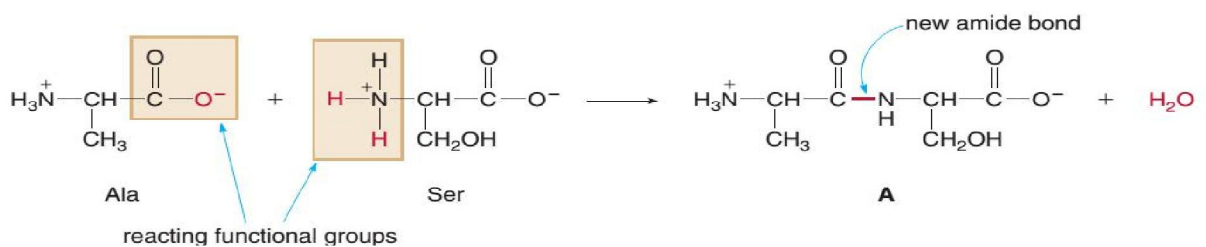
❖ A **tripeptide** has three amino acids joined together by two amide bonds.



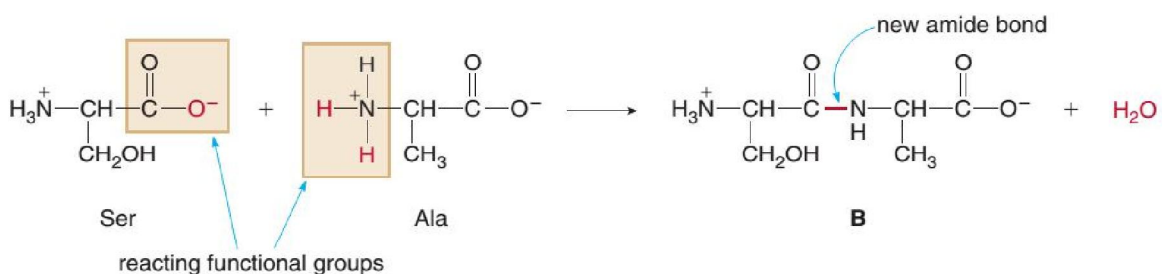
[Amide bonds are shown in red.]

❖ To form a dipeptide, the -NH_3^+ group of one amino acid forms an amide bond with the carboxylate (-COO^-) of another amino acid, and the elements of H_2O are removed. Because each amino acid has both functional groups, two different dipeptides can be formed.

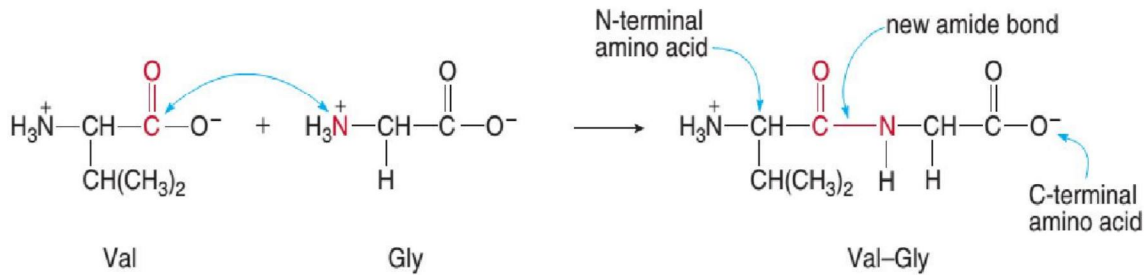
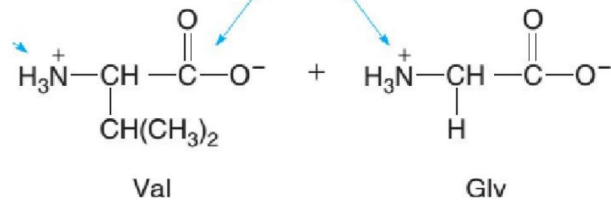
1. The -COO^- group of alanine can combine with the -NH_3^+ group of serine.



2. The -COO^- group of serine can combine with the -NH_3^+ group of alanine.



Place these two groups next to each other.



Protein Structure

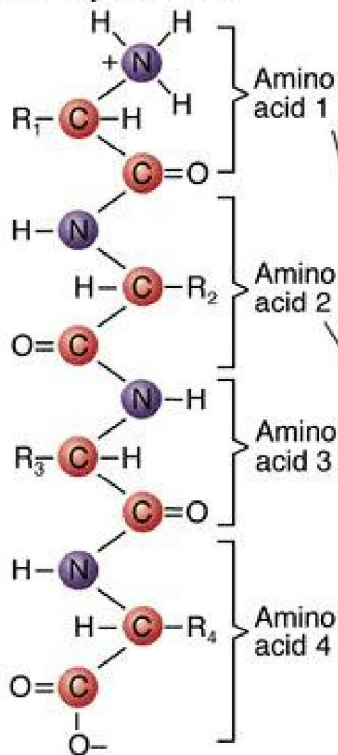
Primary

Secondary

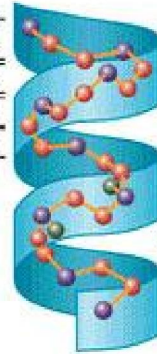
Tertiary

Quaternary

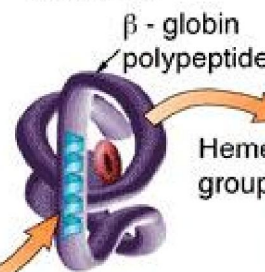
Primary structure



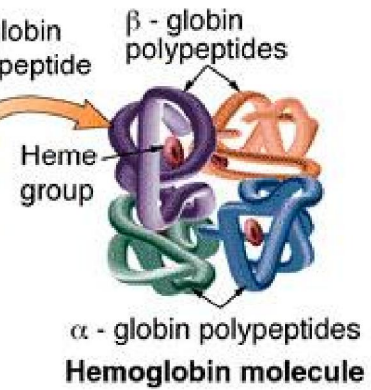
Secondary structure (α helix)



Tertiary structure



Quaternary structure



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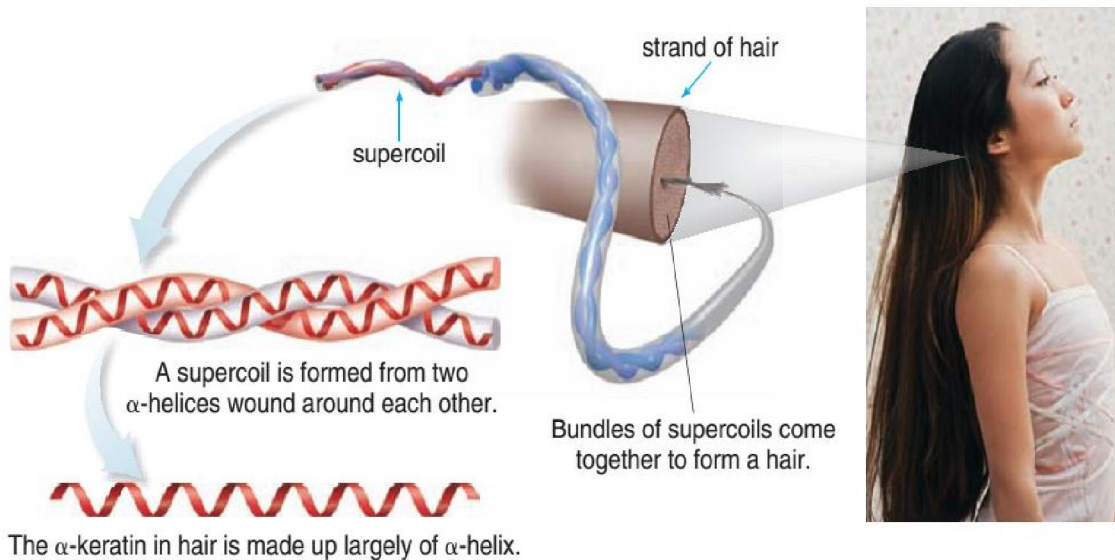
α -KERATINS

α -Keratins are the proteins found in hair, hooves, nails, skin, and wool.

They are composed almost exclusively of long sections of α -helix units, having large numbers of alanine and leucine residues.

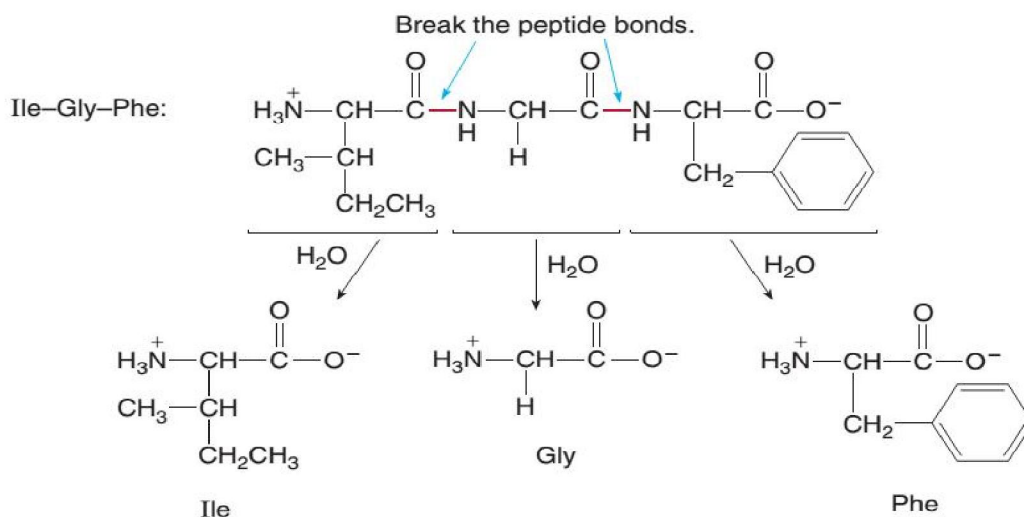
Since these nonpolar amino acids extend outward from the α -helix, these proteins are very insoluble in water. Two α -keratin helices coil around each other, forming a structure called a supercoil or superhelix.

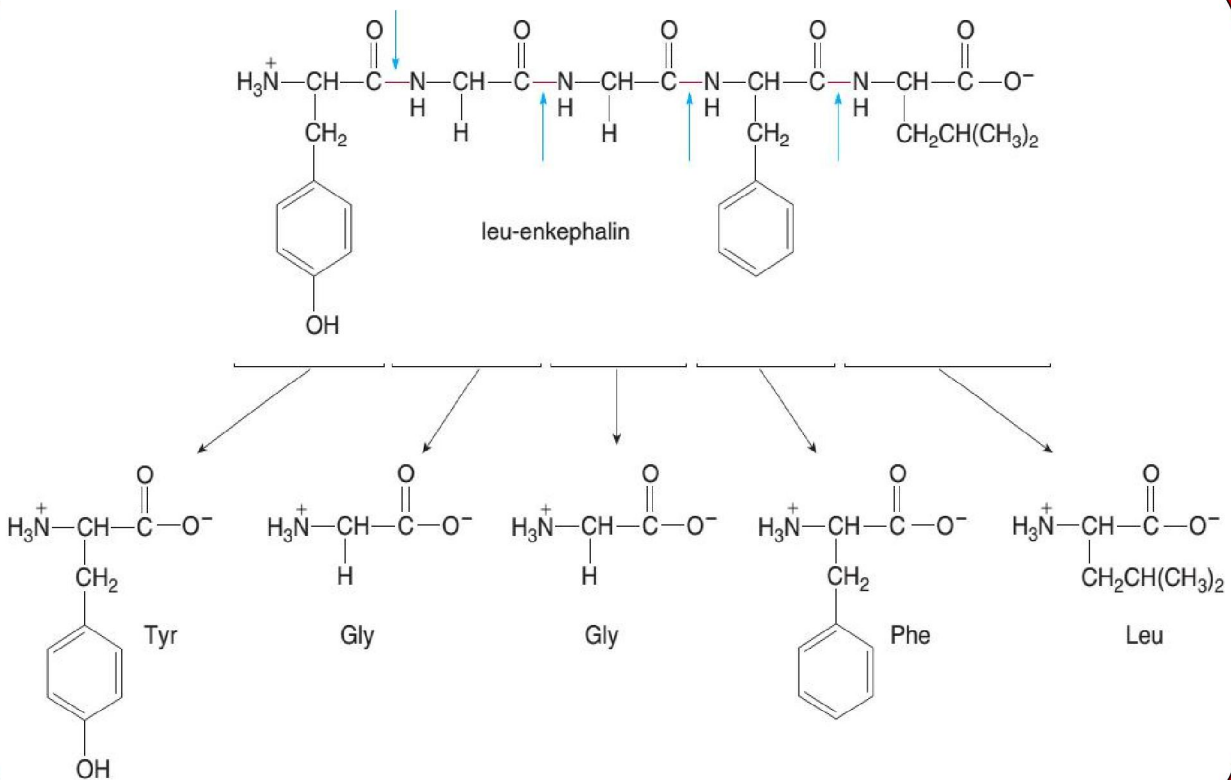
▼ **FIGURE 21.12** Anatomy of a Hair



PROTEIN HYDROLYSIS

The hydrolysis of the amide bonds in a protein forms the individual amino acids that comprise the primary structure.





Forces Stabilizing The Structures

Ionic

Covalent

Hydrogen bonding

Metal chelating

PROTEIN DENATURATION

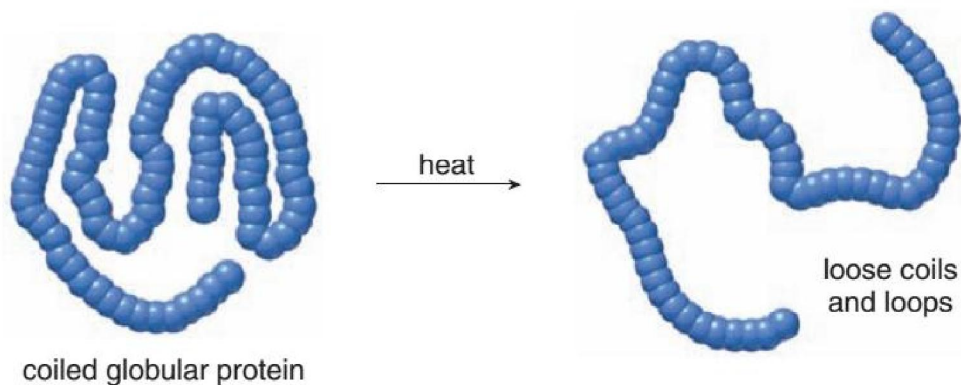
Denaturation is the process of **altering the shape** of a protein **without breaking the amide bonds** that form the **primary structure**

❖ **High temperature, acid, base**, and even agitation can disrupt the **noncovalent interactions** that hold a protein in a specific shape.

❖ **Heat breaks up weak vander waals (London forces) between nonpolar amino acids.**

Heat, acid, and base disrupt hydrogen bonding interactions between polar amino acids, which account for much of the secondary and tertiary structure.

❖ **As a result, denaturation causes a globular protein to uncoil**



-
- ❑ **Denaturation often makes globular proteins less water soluble. Globular proteins are typically folded with hydrophobic regions in the interior to maximize the interaction of polar residues on the outside surface with water. This makes them water soluble.**
 - ❑ **When the protein is denatured, more hydrophobic regions are exposed and the protein often loses water solubility.**
 - ❑ **As milk ages it becomes acid from enzymes that produce lactic acid. The acid also denatures milk proteins, which precipitate as an insoluble curd.**



Cooking or whipping egg whites denatures the globular proteins they contain, forming insoluble protein.

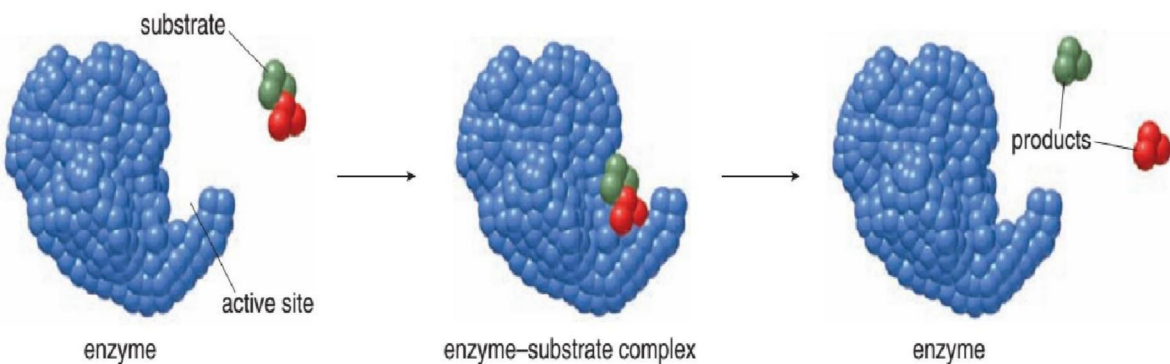
- ❑ **Ovalbumin, the major protein in egg white, is denatured when an egg is boiled or fried, forming a solid.**

ENZYMES

proteins that serve as biological catalysts for reactions in all living organisms

- Enzymes greatly enhance reaction rates. An enzyme-catalyzed reaction can be 10^6 to 10^{12} times faster than a similar uncatalyzed reaction.
- Enzymes are very specific.

HOW ENZYMES WORK



Two models have been proposed to explain the specificity of a substrate for an enzyme's active site: the **lock-and-key model** and the **induced-fit model**.

- A *reversible* inhibitor binds to an enzyme but then enzyme activity is restored when the inhibitor is released.
- An *irreversible* inhibitor covalently binds to an enzyme, permanently destroying its activity.

Common Enzymes Used for Diagnosis

Enzyme	Condition
Creatine phosphokinase	Heart attack
Alkaline phosphatase	Liver or bone disease
Acid phosphatase	Prostate cancer
Amylase, lipase	Diseases of the pancreas